

A NEW SPECIES OF *LITORIA* (ANURA: HYLIDAE) FROM NEW GUINEA AND A REDEFINITION OF *LITORIA LEUCOVA* (TYLER, 1968)

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At present *Litoria leucova* is known from the holotype collected at Busilmin near the north flowing May River and seven specimens from the south flowing Ok Tedi in the Star Mountains of New Guinea. We show that the specimens from the north and south faces of the central mountains represent two distinct species. This paper describes the southern taxon as *Litoria majikthise* sp. nov. and redefines *L. leucova* confining it to the northern taxon. □
Hylidae, Litoria leucova, Litoria majikthise, new species, New Guinea.

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Litoria leucova (Tyler, 1968) was described from a single adult female collected from Busilmin near the May River on the northern slopes of the Star Mountains of Papua New Guinea. Menzies (1993) redescribed the species based on seven specimens from the south flowing Ok Tedi, without reference to the holotype, and placed it in the *Litoria nigropunctata* species group.

During field work in the Western and Sandaun Provinces of Papua New Guinea we collected specimens which, after comparison with type material, made it clear that *L. leucova* as defined by Menzies (1993) is polytypic. The specimens Menzies (1993) referred to *L. leucova* are not this species but represent an undescribed species. In this paper we report further specimens of *L. leucova* and describe and illustrate the new species.

MATERIALS AND METHODS

Eight morphometric measurements (in mm) were made of specimens of *Litoria iris*, *L. leucova* and the new species held in the South Australian Museum (SAM) and the University of Papua New Guinea (UPNG). These measurements were: snout-vent length (SVL), head width (HW), head length (HL), eye diameter (ED), eye to naris interval (EN), internarial span (IN), tibia length (TL) and foot length (FL) following Tyler (1968).

Descriptive statistics and a number of morphometric ratios were calculated from these measurements. All measurements and proportions given are for adult males unless otherwise stated. A discriminant function analysis (Rey-

ment, et al., 1984) was done to test for significant multivariate differences in raw measurements between the three taxa.

Calls were recorded in the field with a SONY Professional Walkman cassette recorder and an Electret Condenser microphone ECM Z200. Calls were analysed using ULTRASOUND v1.10 (Jordan, 1988).

COMPARISONS

Litoria leucova was originally diagnosed on the basis of a single female with: 1, SVL = 30.4mm; 2, an immaculate blue dorsum and stippled blue on the thighs; 3, an eye to naris distance less than internarial span; 4, no vomerine teeth; 5, an immaculate unpigmented ventral surface; 6, no flash markings in the groin or on posterior surfaces of thighs; and 7, unpigmented ova (Tyler, 1968). This specimen was collected on the northern slopes of the Star Mountains.

The specimens Menzies (1993) referred to as *L. leucova* were all male and quite different from the holotype: they were larger (SVL = 31.0-35.4mm), mottled on the dorsum, had bright red flash markings in the groin and on the hidden surfaces of the thighs, large purple patches on the ventrolateral surfaces, and possessed vomerine teeth. All of these specimens were from the southern slopes of the Star Mountains.

Since the holotype was female and all of Menzies' (1993) specimens were male, these differences may have reflected sexual dimorphism in one species. However, this is unlikely for a number of reasons. Firstly, male Anura are usually smaller than females. The existence of a species with a reversal of this pattern would be

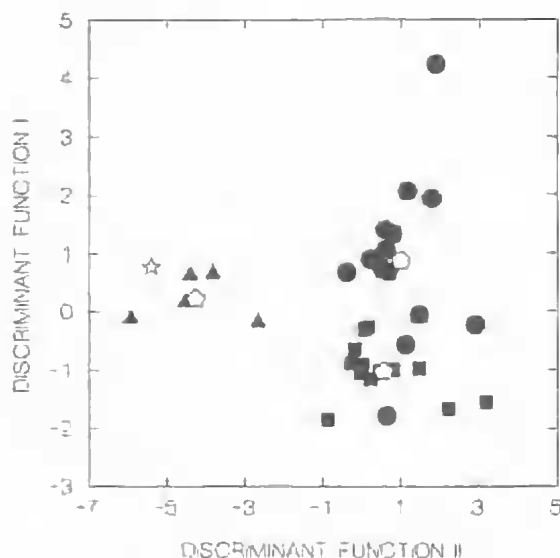


FIG. 1. Plot of individual *Litoria iris* (circles), *Litoria leucova* (triangles) and *Litoria majikthise* (squares) on the first two discriminant function axes based on seven measurements. Hollow pentagons = group centroids. Hollow star = holotype of *Litoria leucova*.

very unusual, especially in the absence of morphological or behavioural indications that male combat is important in this species (Shine, 1979). Secondly, we have collected a female of the 'southern' taxon and found it to be larger than males (SVL=39.2mm) but entirely consistent with them in all other respects. Thirdly, several males collected near the type locality of *L. leucova* correspond in all respects to the holotype of that species, but differ from males of the southern taxon in morphology and structure of the mating call.

Thus, two separate taxa, from the southern and northern slopes of the Star Mountains, appear to be included in Menzies' (1993) concept of *L. leucova*. This hypothesis was tested using a discriminant function analysis of seven measurements using *L. iris*, the southern and northern *L. 'leucova'* as a priori groupings (Fig. 1). *L. iris* was included in this analysis because phenetically it is the species of *Litoria* most similar to the southern taxon.

There were two significant discriminant functions, the first of which accounted for 81.4% of the variance. All measurements contributed significantly to decrease Wilk's Lambda. The analysis resulted in correct identification of 93.8% of specimens overall. All *L. iris* and northern *L. 'leucova'*, and 85.7% of southern

L. 'leucova' were correctly identified. All misidentified southern frogs were assigned to the group representing *L. iris* by the analysis. A posteriori placement of the type specimen of *L. leucova* onto the discriminant functions demonstrated clearly that it falls within the northern cluster, but well outside of the clusters representing *L. iris* and the southern taxon. On the basis of this morphological analysis and differences in mating call we describe the southern *L. 'leucova'* as a new species, and redefine *L. leucova* (*sensu stricto*) to include only northern specimens.

***Litoria majikthise* sp. nov.**
(Figs 1-4)

MATERIAL EXAMINED

HOLOTYPE: SAMR44093, 6km SSW Tabubil, Western Province, Papua New Guinea, 5°18'S, 141°12'E, G.R. Johnston, S.J. Richards, 10.vii.1993, male.

PARATYPES: UPNG6734, Megalsimbip, Ok Menga, Western Province, Papua New Guinea, 5°18'S, 141°20'E, J.C. Pernetta, vii.1981; UPNG7305-7309, Lower Kam valley, Western Province, Papua New Guinea, 5°12'S, 141°14'E, J. Menzies, i.1985; UPNG8501-8508, 6km SSW Tabubil, Western Province, Papua New Guinea, 5°18'S, 141°12'E, S.J. Richards, G.R. Johnston, 28.xi.1991; SAMR44094, 11km SSW Tabubil, Western Province, Papua New Guinea, 5°21'S 141°12'E, G.R. Johnston, S.J. Richards, 22.vii.1993; SAMR44095-44101, 6km SSW Tabubil, Western Province, Papua New Guinea, 5°18'S 141°12'E, G.R. Johnston, S.J. Richards, 9-10.vii.1993; UPNG8602-03, 12km S Tabubil, Western Province, Papua New Guinea, 5°22'S 141°17'E, G.R. Johnston, S.J. Richards, 1-20.vii.1993.

DIAGNOSIS

A member of the *Litoria nigropunctata* species group (Menzies 1972, 1993). Distinguishable from all other members of this group by the following combination of characters: 1, green dorsally in life; 2, snout-vent length 30.5-35.4mm in adult males; 3, thighs and groin crimson in life; 4, purple speckling on lateral surfaces of belly tending to form patches which do not separate distinct large, white lateral patches from venter; 5, distinct white postocular spot; 6, call with dominant frequency of 2.5kHz, a pulse repetition rate of 0.16-0.24 pulses/ms.

DESCRIPTION

Body size small (SVL = 30.5-35.4mm in males, 39.2mm in a female). Head slightly broader than long or as broad as long (HI/HW = 0.81-1.03).

TABLE 1. Measurements of adult male *Litoria iris*, *L. leucova* and *L. majikthise*. Values are means (standard deviations). The measurements are defined in the text. *P* = probabilities associated with oneway ANOVAs comparing the taxa.

Character	<i>L. majikthise</i> (N=14)	<i>L. iris</i> (N=13)	<i>L. leucova</i> (N=5)	P
SVL	32.7 (1.659)	31.4 (3.111)	26.1 (0.391)	0.000
HW	9.8 (0.395)	9.5 (0.647)	8.8 (0.363)	0.006
HL	8.9 (0.622)	8.1 (0.806)	7.6 (0.466)	0.003
ED	4.0 (0.412)	3.6 (0.456)	3.0 (0.164)	0.000
EN	3.0 (0.283)	2.6 (0.166)	2.3 (0.123)	0.000
IN	3.6 (0.181)	3.5 (0.420)	2.7 (0.205)	0.000
TL	18.4 (0.547)	18.2 (1.719)	14.2 (0.383)	0.000

Head length about one quarter of body length (HL/SVL = 0.24–0.29). Snout prominent, round when viewed from above and slightly round to truncate in profile. Nostrils lateral. Eye-to-naris distance less than or equal to internarial span (EN/IN = 0.72–1.03). Nostrils much closer to end of snout than eye. Canthus rostralis rounded, concave and slightly to well defined. Eyes large and protuberant, eye diameter generally greater than distance from eye to nostril (ED/EN = 0.97–1.55). Tympanum covered with skin, one third to one half of eye diameter. Vomerine teeth on two slight elevations between the choanae. Tongue broad and oval in shape.

Fingers short with moderate lateral fringes; finger lengths $3 > 4 > 2 > 1$. Terminal discs large. Webbing to subarticular tubercle at base of penultimate phalanx of fourth finger. Hindlimbs moderately long (TL/SVL = 0.53–0.60); toe lengths $4 > 3 > 5 > 2 > 1$. Webbing between toes to base of disc on all toes, except fourth and fifth. Webbing on fourth toe to base of penultimate phalanx. Webbing on fifth toe reaches midway along penultimate phalanx, continuing to disc via a narrow fringe. A small, oval inner metatarsal tubercle present; no outer metatarsal tubercle.

Skin of dorsal surfaces minutely tubercular. Throat and chest slightly granular. Few tubercles on posterior surface of forearm and outer edge of each foot. Few conspicuous tubercles on ventromedial surfaces of thighs, below anus. Posterior surface of thighs generally smooth, but interrupted by few large tubercles. Supratympanic fold inconspicuous.

In preservative dorsal surfaces immaculate blue (one specimen) or densely mottled with darker blue (all other specimens). Ventral surfaces generally cream to white, but ventral sur-

faces of hindlimbs, concealed parts of thighs, groin and in some specimens much of the belly pale pink. Lateral surfaces of throat and body with blue-grey stippling, sometimes developing into large dark patches in the groin and on throat. Some stippling may also occur on the posterior surface of thighs. A distinct, broad white postocular bar between eye and forelimb, running below the tympanum.

In life dorsal surfaces immaculate dark green or pale emerald green with darker green mottling. Ventral surfaces generally white; ventral surfaces of hindlimbs and belly red. Lateral surfaces of throat and body speckled with purple, sometimes developing into large dark purple patches in the groin and on throat. Stippling also present on posterior surface of thighs in some specimens. A distinct broad, pearl-white postocular bar, between eye and forearm, below tympana. Iris golden yellow.

Measurements of holotype (in mm). SVL = 34.0; HL = 9.0; HW = 10.8; ED = 4.5; EN = 3.1; IN = 3.9; TL = 18.7; FL = 23.1.

MATING CALL

Two types of call are uttered (Fig. 4B,D). One is a short (26–80ms, mean = 40, SD = 18.06, N = 7), harsh 'chip' consisting of 6–16 pulses (mean = 8.9, SD = 3.29) at a pulse rate of 0.20–0.24 pulses/ms (mean = 0.22, SD = 0.013). This short call begins at 2.2–3.2kHz and finishes at 1.4–4.3kHz, but has a dominant frequency around 2.5kHz. The second longer (290–360ms, mean = 330, SD = 36.1, N = 3) call is a harsh 'raagh', increasing in volume, consisting of 49–63 pulses (mean = 57.3, SD = 7.37) at a rate of 0.16–0.19 pulses/ms (mean = 0.174, SD = 0.010). This long call begins at 1.8–2.2kHz and ends at 1.8–5.0kHz, but has a dominant frequency around 2.5kHz. A number of individual frogs were heard to utter both short and long calls (including the holotype). Twenty calls uttered by four individuals gave a mean call rate of one per 26s. All calls were recorded at temperatures of 21.0 to 22.2°C.

ETYMOLOGY

From 'Majikthise' a farcical comedy character (Adams, 1979), referring to the vividly coloured thighs and groin.

DISTRIBUTION AND HABITAT

Known only from altitudes between 550 and 650m in the headwaters of the south draining Ok Tedi in the Star Mountains. Specimens were collected at night on foliage at the edge of cultivated



FIG. 2. A, B, *Litoria majikahise*; C, *Litoria leucova*. A, C, lateral views; B, ventral view.

sago swamps, among grasses in uncultivated swamps and on vegetation along a roadside ditch, all within 15km of the township of Tabubil. Perch heights varied between 1.0m and 2.5m.

Litoria leucova (Tyler, 1968)
(Figs 1-4)

Hyla leucova Tyler, 1968: 119.

MATERIAL EXAMINED

HOLOTYPE: SAMR6461, Busilmin, Sandaun Province, Papua New Guinea, 4°55'S 141°00'E, B. Craig, 1.v.1965, female.

OTHER MATERIAL: SAMR44091-44092, UPNG8604-06, Stolle Mountain, Sandaun Province, Papua New Guinea, 4°48'S 141°39'E, G.R. Johnston, S.J. Richards, 4.vii.1993.

DIAGNOSIS

Distinguishable from all other Papua New Guinean *Litoria* by the following combination of characters: 1, Green dorsally in life; 2, Snout-vent length 30.5-35.4mm in adult males; 3, thighs and groin translucent pink with yellow spots in life; 4, no purple speckling on lateral surfaces of belly; 5, no white postocular spot; 6, calls with dominant frequency of 4.0-5.0kHz, a pulse repetition rate of 0.11 pulses/ms.

DESCRIPTION

Body size small (SVL=30.5-35.4mm in males, 30.4mm in a female). Head slightly longer than broad (HL/HW=0.81-0.91). Head length about one third of body length (HL/SVL=0.26-0.31). Snout not prominent, round when viewed from above and truncate in profile. Nostrils lateral. Eye-to-naris distance less than internarial span (EN/IN=0.78-0.96). Nostrils closer to end of snout than to eye. Canthus rostralis straight and slightly defined. Eyes moderate in size, not prominent. Eye diameter fractionally greater than distance from eye to nostril (ED/EN=1.25-1.43). Tympanum visible, one half of eye diameter. Vomerine teeth absent. Tongue oval in shape with strongly indented posterior border.

Fingers short with broad lateral fringes; finger lengths $3 > 4 > 2 > 1$. Terminal discs large. Webbing to subarticular tubercle at base of penultimate phalanx of fourth finger. Hindlimbs long and slender (TL/SVL=0.53-0.55); toe lengths $4 > 5 > 3 > 2 > 1$. Webbing between toes to base of disc on all toes, except fourth. Webbing on fourth reaches halfway up penultimate phalanx and connected to disc by broad lateral fringe. Small, oval inner metatarsal tubercle present; no outer metatarsal tubercle.

Skin of dorsal surfaces smooth, except for weakly tubercular upper eyelids. Throat smooth. Chest and anterior portion of abdomen, and ventral surfaces of thighs granular. Large prominent tubercles on ventromedial surfaces of thighs, below anus. Supratympanic fold prominent, extending from posterior corner of eye, covering upper rim of tympanic annulus.

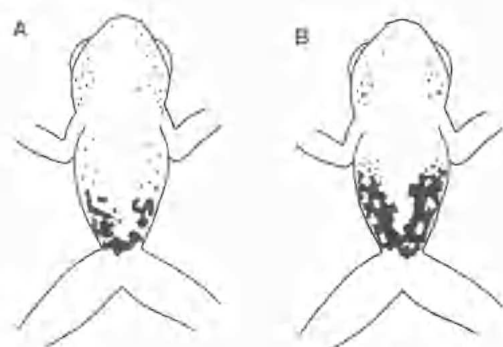


FIG. 3. A, *Litoria majikthise*; B, *L. iris*. Ventral view showing that the purple (black) of *L. majikthise* does not separate distinct white lateral patches from the remainder of the venter as it does in *L. iris*.

In preservative dorsal surfaces immaculate dark blue. Ventral surfaces white. Hidden surfaces of the thighs stippled with dark blue; this stippling is absent from numerous small circular areas so that ground colour appears in the form of circular spots. Subanal tubercles creamish white.

In life dorsal surfaces pale emerald green with occasional paler green spots on some individuals. Ventral surfaces generally white. Thighs and anterior lateral surfaces translucent pink with yellow spots. Iris golden yellow.

MATING CALL

Two types of call were uttered (Fig. 4A,C). One is a short (15–20ms, $N=23$), harsh 'chip' consisting of a single pulse. This short call begins at 3.5–6.0kHz for 10–15ms, then broadens to 2.0–6.0kHz for the last 5ms. The dominant frequency was 4–5kHz. The second longer (90ms, $N=1$) call is a harsh 'raagh', consisting of 10 pulses at a rate of 0.11 pulses/ms. This call began with three pulses between 4.0 and 5.5kHz, followed by nine pulses between 2.0 and 5.5kHz. The dominant frequency was 4.0–5.0kHz for the first nine pulses and then shifted to 2.0–3.0kHz for the last pulse. Two individuals were heard to utter both short and long calls in long, series. Twenty four calls by a single frog gave a mean call rate of one per 2.6s for short calls and one call per 60 s for long calls. Calls were recorded at a temperature of 17.6 °C.

DISTRIBUTION AND HABITAT

Known only from two localities on the northern slopes of the central mountains. Specimens were collected while they called from piles of sticks overhanging streams running into a recently

cleared swamp and from vegetation overhanging a swift-flowing stream at 1600m altitude.

COMPARISON OF *LITORIA LEUCOVA* WITH *L. MAJIKTHIS*

Litoria leucova is smaller and therefore differs in most absolute body measurements from *L. majikthise* (Table 1). The correlations between the measurements and the discriminant functions indicate that, apart from its smaller size, *L. leucova* has a longer head, more prominent snout and smaller eyes than *L. majikthise*. Vomerine teeth are absent in *L. leucova* but present in *L. majikthise*.

The two species also differ in colour (Fig. 2). In life the presence of crimson red in the groin and on the thighs in *L. majikthise* clearly differentiates it from *L. leucova*, in which the thighs are translucent pink with yellow spots. However, this difference is less clear in preserved specimens as the crimson colour of *L. majikthise* fades. The presence of purple stippling on the ventrolateral surfaces of the body clearly distinguish *L. majikthise* from *L. leucova*, in which the ventral surface is white. All but one specimen of *L. majikthise* was strongly mottled dorsally, whereas *L. leucova* is generally immaculate pale green dorsally with the occasional paler spot on some individuals. The only *L. majikthise* to lack dorsal mottling was dark green on the dorsum. A pearly white postocular spot is present in *L. majikthise*, but absent in *L. leucova*.

The calls of *L. leucova* have a higher dominant frequency (4–5kHz) than those of *L. majikthise* (2–3kHz). Both species utter distinct short and long calls. The short calls of *L. leucova* consist of a single pulse and are 15–20ms long, whereas the short calls of *L. majikthise* consists of 6–16 pulses and are 26–80ms long. A single long call of *L. leucova* consisted of 10 pulses and was 90ms long, whereas the long call of *L. majikthise* was longer (290–360ms) and contained more pulses (49–63). *L. leucova* calls at a much faster rate (1 call/2.6s) than does *L. majikthise* (1 call/26s), so that it is difficult to know whether the series of short and long calls uttered by *L. leucova* is a series of separate mating calls or a single call consisting of these subunits.

Litoria leucova occurs at much higher altitudes (1600m) than does *L. majikthise* (550–650m). They may also differ in habitat preferences; *L. majikthise* was found in swamps or along a small, slow-flowing creek, whereas *L. leucova* was found calling from streams flowing through a

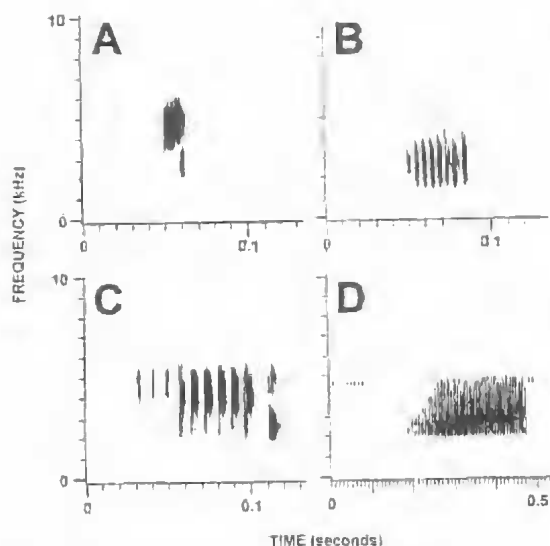


FIG. 4. Sonograms of calls. A,C, *Litoria leucova*; B,D, *L. majikthise*, holotype. Upper: short call. Lower: long call. Note that the scales on the abscissae differ between panel D and all other panels.

cleared area that had until recently been a swamp and along a well vegetated, swiftly flowing stream.

COMPARISON OF *LITORIA MAJIKTHISIE* WITH OTHER SPECIES OF *LITORIA*

Litoria majikthise has purple ventrolateral patches in common with *L. iris* and *L. ollauru* (Menzies, 1993), and which distinguishes these three species from all other species of *Litoria*. The purple patches of *L. majikthise* are smaller than those in *L. iris*, and do not separate distinct large, white lateral patches from the venter as in *L. iris* (Fig. 3). *L. majikthise* has crimson in the groin and on the thighs, whereas *L. iris* has yellow to orange and *L. ollauru* has orange (Tyler, 1962; Menzies, 1993).

In the Ok Tedi area *L. iris* occur within 20 kilometres of *L. majikthise* (Hyndman & Menzies, 1990), but *L. iris* is a montane species and occurs at much higher altitudes (1300–2300m; Tyler, 1968) than does *L. majikthise*.

Comparison of the call of *L. majikthise* with that of *L. iris* (based on Menzies, 1972, 1993) show no differences in the fundamental frequency, but the pulse rate is lower in *L. iris* (0.09–0.10 pulses/ms) than in *L. majikthise* (0.16–0.24 pulses/ms). Menzies (1975) described the call of *L. iris* as a slow buzzing or spluttering which is

clearly distinguishable from the harsh 'chip' or a harsh 'raagh' of *L. majikthise* (Menzies, 1993; pers. obs.).

COMPARISON OF *LITORIA LEUCOVA* WITH OTHER SPECIES OF *LITORIA*

Tyler & Davies (1978) placed *L. leucova* in a monotypic species group, defined by being small, uniformly green, montane frogs, with short, half-webbed fingers, fully webbed toes and unpigmented eggs. Tyler (1968) noted that the granules on the ventral surface of the holotype of *L. leucova* tend to form transverse ridges. Examination of the type and live specimens suggest that this characteristic is an artefact of preservation and not a structural feature of the frogs themselves.

The only other species of similar size to *L. leucova* which lay unpigmented eggs include some members of the *L. nigropunctata* group and all members of the *L. becki* group (sensu Tyler & Davies, 1978). Species in the *L. becki* group differ from *L. leucova* in having long unwebbed (vs short 1/3 webbed) fingers and a ventral surface variegated with dark pigments (vs white). *L. leucova* is similar to members of the *L. becki* group in that it has been found along a swiftly flowing mountain stream, but some *L. leucova* were collected from small streams which flowed through what had recently been a swamp. Thus the true habitat preferences of *L. leucova* are difficult to assess.

Of the species belonging to the *L. nigropunctata* group, *L. leucova* differs from *L. havina* Menzies, 1993, *L. mucro* Menzies, 1993 and *L. pronimia* Menzies, 1993 in that males lack a rostral spike (Menzies, 1993). *L. vocivincens* Menzies, 1972 occurs only on the southern lowlands of New Guinea and the hidden surfaces of the thighs are black (vs pink) (Menzies, 1972). *L. ollauru* and *L. iris* have large purple ventral patches, which *L. leucova* lacks (Tyler, 1962; Menzies, 1993). Dorsally *L. nigropunctata* (Meyer, 1874) is usually brown or green-brown (vs pale green) and the hidden surfaces of the thighs are black (vs pink) (Menzies, 1972). *Litoria chloronata* (Boulenger, 1911) is the species which most closely resembles *L. leucova* in the *L. nigropunctata* groups, but its call has a lower dominant frequency (2.6kHz) than *L. leucova* and the concealed surfaces of the thighs and groin are bright orange (Menzies, 1993). The only species in the *L. nigropunctata* group that occur at altitudes higher than 1000m is *L. iris*.

Litoria leucova differs from most congeners in lacking vomerine teeth. *Litoria chloronata* and some *L. iris* share the lack of vomerine teeth with *L. leucova* (Tyler, 1962, 1968) as do members of the *L. bicolor* species group (Tyler & Davies, 1978). *Litoria leucova* differs from all members of the *L. bicolor* group in being of more robust habitus, and having unpigmented eggs.

Litoria leucova shares features in common with members of both the *L. becki* and the *L. nigropunctata* species groups of Tyler & Davies (1978). Unfortunately, neither of these groups can be defined by a single synapomorphy, and are almost certainly not monophyletic. Indeed, there is little correspondence between hypothesised relationships among species of *Litoria* based on morphological (Tyler & Davies, 1978), karyotypic (King, 1981) and immunological data (Hutchinson & Maxson, 1987). We have tentatively referred *L. majikihise* to the *L. nigropunctata* group because of its obvious similarity to *L. iris*, a species which has long been included in this group (Menzies, 1972, 1993). The affinities of *L. leucova* are less clear and will only be resolved by a thorough phylogenetic analysis of this speciose genus based upon all available data.

COMPARATIVE MATERIAL EXAMINED

Litoria iris: UPNG4434, 4478-79, Moiyakabip, Hindenberg Range; UPNG2318, UPNG7313-7318 Bakonabip; UPNG2101, Margariaua; UPNG2117-2158, 2241-2281, Nipa; UPNG3115-3135, Tari; UPNG3150-3178, Komo; UPNG3674, 5528, Mendi; UPNG3844, Tambul; UPNG8289-90, Ubaigubi Lodge; UPNG6992-3, 7168, 7655, Mt Gilewe; UPNG5812-13, 5898-5903, Halalinja via Nipa; UPNG7023-7024, Angalimp camp; UPNG7148-7167, Porgera; SAM5241, Okapa; SAM5423, 5874, Telefomin; SAM5726, Dumun.

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